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EXPERIMENTS WITH STEAM DISINFECTORS IN DESTROYING LICE IN CLOTHING

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It has been shown by Nuttall (1918) that "the high standards of efficiency attained by regular disinfectors on the basis of their capability of dealing with bacteria or their heat-resisting spores do not appear necessary for mere louse destruction." This paper deals with the minimum requirements, as regards pressure, time and temperature, for louse destruction only. The question of sterilization does not enter.

The work was done at Camp Mills, L. I., N. Y., in response to a request from the Camp Surgeon to Dr. L. O. Howard, Chairman of the Subcommittee on Entomology, Medical Committee, National Research Council. The request was made at the suggestion of D. L. Van Dine, Captain, Sanitary Corps, who was in charge of the Sanitary Process Plants at Camp Mills, and the work was done in close cooperation with him and with Captain H. L. Gardiner, M. C., Assistant Officer in Charge, in an attempt to answer certain practical problems they had in mind. The principal question was whether the disinfecting process in use at these plants was effective in destroying lice in the clothing, and whether the process would still be effective if the time of treatment were shortened—thus increasing the daily capacity of the plants.

There are two Sanitary Process Plants in operation at Camp Mills. One, referred to as Plant No. 1, is built largely on plans and specifications from Major Harry Plotz (1919) of the Surgeon General's Office. The other, referred to as Plant No. 2, is "home made," so to speak. The nucleus of this plant was an old bath house, and the present establishment is the result of a process of addition and modification dictated by practical experience. Each plant consists essentially of

(1) Disrobing room. Here the men place blankets, overcoats and all other articles of clothing, except leather and rubber goods, in a barracks bag which is issued to them at the entrance. The bags are tied and tagged and placed in the carrier of the sterilizer.

(2) Bath; after a medical inspection the men pass into a bathroom where they are first painted with a kerosene emulsion, then pass to the showers. Here the amount of hot and cold water is not restricted, and the soap supply is liberal, and the men have time for a thorough bath. Those who, on inspection, are found infested with crab lice,

Phthirius pubis, are turned aside to a barber shop where axillary and pubic regions are shaved, after which they pass on into the bathroom.

(3) Drying and dressing room. Here the men dry themselves and are issued bath robes while waiting to receive their clothing from the sterilizers.

(4) Sterilizers. These are the essential factors in the destruction of lice in the clothing. At Plant No. 1 there is installed a large stationary sterilizer which measures about 18½ feet long and 5 feet in diameter. At Plant No. 2 there are twenty portable steam disinfectors arranged in two rows of ten each on opposite sides of a large shed. Each disinfector is rectangular and measures 30 by 42 by 84 inches.

The capacity of Plant No. 1 (February and March, 1919) was seventy men every 40 minutes; of Plant No. 2, 100 men every 40 minutes. The experiments reported below bear upon the question of the efficiency of these disinfectors.

SOURCE OF MATERIAL AND METHOD USED

The species dealt with is the body or clothing louse, *Pediculus humanus,* var. *corporis.* The stock lice were from material which had been reared through several generations during the preceding six months on a healthy individual. This stock was taken from Washington to Camp Mills by the writer. Volunteers were called for from the enlisted personnel of the Medical Detachment to act as hosts for the lice. Two men responded and were assigned by Captain Van Dine to the duty of feeding the lice and rendering other assistance in the experiments. The lice were kept in small pill boxes. These boxes are prepared by punching holes in both top and bottom and covering these openings with chiffon. Each box contained from 50 to 100 lice, together with a piece of cloth to which the lice cling, and to which they attach their eggs. For the purpose of feeding, these boxes were applied to the arm of the volunteers and held in place by means of elastic bands. This was done twice daily, and in the intervals between feedings, the boxes were kept in an electrically heated incubator at a constant temperature of 30° C. Every second day the lice were transferred to clean bits of cloth and returned to the boxes. The eggs or nits on the old piece of cloth, from which the lice had been removed, were counted, and each lot of eggs was put in a separate box. These were labeled and kept in the incubator. In the experiments these eggs were used as the test materials, on the assumption that any means which will destroy the nits will also destroy the active stages of lice, it being a matter of common experience that the nits are the more resistant. When the eggs were subjected to tests they were removed from the boxes and put in the pocket of a coat, blouse or shirt or inside a woolen sock, thus approximating the conditions of natural infestation. In most cases a woolen sock was used, the bit of cloth with nits attached was put in the toe of the sock, and then a maximum registering thermometer was put in so that the bulb was near the eggs. The sock was then tagged and placed in the roll of clothing of some one of the men who were "going thru the mill" at the time.

The treatment to which the clothing is subjected consists of a preliminary vacuum, 10 inches, for 5 minutes; steam, 15 pounds for 15 minutes, reckoned from time steam is turned on; drying vacuum, 10 inches for 10 minutes.

Steam under 15 pounds pressure gives a theoretical temperature of about 250° F. (121° C.), and on several occasions maximum thermometers gave actual readings of 245° F. (118° C.). This temperature is developed only in the superficial layers of the bags as a rule. The temperature in the center of a mass of goods in a bag seldom goes so high, and then only in bags lightly and loosely packed and not subjected to pressure from weight of other bags above or alongside them. Whether a temperature sufficient to kill is developed in the center of a well packed bag depends on factors influencing the penetration of steam. Some of the factors are:

(1). The manner of packing the bags. The usual method was to spread out the three blankets, folded once lengthwise, on the floor, then the overcoat, blouse and other articles of clothing were arranged on top of these and the whole rolled up and put in the bag. There was, however, a great deal of variation in the way the roll was made up.

(2). The location of the bag in the load. It is obvious that those bags in the center with other bags pressed against them on all sides are more difficult to penetrate than those on the sides or top of the load.

(3). The size of the load. For every carrier there is a certain load beyond which more compression is necessary, which renders it most difficult for steam to penerate within the time limit.

(4) Treatment: Preliminary vacuum; number of inches. Steam under pressure; pounds and time.

(5). The nature of the goods treated, whether wool or cotton, closely or loosely woven.

(6). Moisture and temperature conditions of the goods when placed in the sterilizer.

EXPERIMENTAL DATA

The principal question as to whether the daily capacity of the plants could be increased by shortening the period of treatment of each lot was answered in the negative.

EXPERIMENT 1.—A load of twenty-five barracks bags filled with bath robes was given a very short treatment as follows: Preliminary vacuum, 5 minutes, 10 inches; steam, 5 minutes, 14 pounds reached; drying vacuum, 10 inches, 10 minutes. Lots of eggs and maximum thermometers were placed in center of two of the bags, one of which was located in the center of the load and one on top. In neither case were the eggs killed.

The two following experiments in which the period of exposure to steam was 10 minutes were done at the large sterilizer at Plant No. 1.

EXPERIMENT 2.—Bits of cloth with the nits attached were put in pockets of each of three wool blouses. A maximum registering thermometer was rolled up in each blouse in such a way that the bulb was in close proximity to the spot where the eggs were located. Each blouse was then put in center of a barracks bag filled with bath robes. These two bags were placed in the carrier with twenty-five other bags filled with bath robes.

Results

Bag	Number of Eggs	Age of Eggs, Days	Maximum Temperature Recorded	Number Hatched	Percentage
A	165	5-7	34.5 C.	116	70.3
B	170	5-7	99.5 C.	0	0
C	158	3-5	77 C.	0	0
Control lot	75	5-7	30 C.*	53	70.6

* Incubator.

Location of Bags in Load.—Bag A was placed in the center of the load. Bags B and C were placed on top.

Treatment.—Preliminary vacuum, 10 inches, 5 minutes; steam, 15-18 pounds, 10 minutes (18 pounds reached at end of 10 minute period); drying vacuum, 10 inches, 10 minutes.

EXPERIMENT 3.—Twenty-five barracks bags were filled with bath robes, and in two of these the test materials were placed. The eggs were put in pockets of a wool blouse. A self-registering thermometer was rolled up in the blouse so that the bulb was near the eggs. The blouse roll was then rolled in four bath robes — thus approximating the conditions of a blouse rolled inside three blankets. The roll above described was put in a bag in which three bath robes had been stuffed in the bottom. The bag was then filled up with other bath robes and tied and tagged.

Results

Bag	Number of Eggs	Age of Eggs, Days	Maximum Temperature Recorded	Number Hatched	Percentage
A	137	2-4	58 C.	94	68.6
B	120	2-4	36 C.	81	67.5
Control lot	105	2-4	30 C.*	84	80.0

* Incubator.

Location of Bags in the Load.—Bag A was placed in the center of the load, with other bags below, above and stacked at the ends. Bag B was placed on top of the load.

Treatment.—Preliminary vacuum, 5 minutes, 10 inches (reached in 3 minutes); steam, 10 minutes, 15 pounds (reached in 3½ minutes, held 6½ minutes); drying vacuum, 10 minutes, 10 inches.

The peculiar case of a higher temperature recorded in the bag in the center of the load than in that one fully exposed on top, can only be explained on the assumption that some difference in the way the bags were packed interfered with penetration of the steam.

The results of these two trials with the 10 minute period for steam show three out of five cases in which eggs were not killed. Such a high percentage of failures demonstrated that the treatment was of too short duration.

A number of tests were made of the process in regular use at this camp, viz., a preliminary vacuum of 10 inches followed by 15 pounds steam pressure for 15 minutes (reckoned from time steam was turned in), and a drying vacuum of 10 inches for 10 minutes. The results indicated that this period could not be shortened; but on the other hand it was shown that the process was adequate provided certain precautions were observed. These have to do with conditions favoring thorough penetration of the steam, and will be discussed after first describing typical experiments in which all the conditions were favorable.

EXPERIMENT 6.—This test was run with the large sterilizer at Plant No. 1 in the course of regular operations and according to the regular procedure. Two wool socks were prepared by placing in each a thermometer and a bit of cloth with nits attached.

Location in Bags.—A was put in center of a roll consisting of three blankets, two O. D. shirts, two suits of underwear, one overcoat, one blouse, one pair breeches, four pair socks and one towel. B was put in center of a roll of three blankets, one overcoat, one blouse, one pair breeches, extra suit of underwear, wrap leggings and cap.

The underwear which the men were wearing was, after inspection, placed in the mouth of the bag on top the roll.

Location in Load.—Actual load was seventy-three bags, a normal load for this sterilizer. Bag A was placed near the center of the third row of bags, with one below and two above it. Bag B was placed on top of the load.

Treament.—Preliminary vacuum, 10 inches reached in 3 minutes; steam, 15 pounds, 15 minutes, 10 pounds reached in 6 minutes, 15 pounds reached in 8 minutes, held remaining 7 minutes; drying vacuum, 10 inches, reached in 5 minutes and held to end of 9 minutes.

Results

Bag	Number of Eggs	Age of Eggs, Days	Maximum Temperature Recorded	Number Hatched	Percentage
A	222	3-5	104.5 C.	0	0
B	310	3-5	93 C.	0	0
Control lot....	125	3-5	30 C.*	83	66

* Incubator.

The two following experiments conducted at Plant No. 2 in the portable steam disinfectors also demonstrate the efficiency of this treatment when carried out properly.

EXPERIMENT 12.—Two wool socks, each containing a thermometer and cloth with nits were used as before.

Location in Bag.—Sock A was put inside a roll of three blankets. This was placed in the bottom of a barracks bag. On top of this roll the overcoat, breeches, sweater, socks and underwear were crowded. Sock B was put in a roll of blankets in the center of the bag. Below the roll in the bottom of the bag was the overcoat, blouse and sweater. Above the roll in the top of the bag were underwear, breeches, shirt, socks, cap and wrap leggings.

Location in Load.—Normal load of ten bags was treated. Larger loads for this size sterilizer necessitate undue packing, resulting in difficulty of penetration. Bag A was placed in horizontal position near the center of the carrier. Bag B was put in a vertical positon at one end of the carrier.

Treatment.—Preliminary vacuum, 10 inches, reached in 1 minute; steam, 15 pounds, reached in 4 minutes, held 11 minutes, total 15 minutes; drying vacuum, 10 inches, reached in 3 minutes, held 7 minutes, total 10 minutes.

Results

Bag	Number of Eggs	Age of Eggs, Days	Maximum Temperature Recorded	Number Hatched	Percentage
A	185	7-9	87.5 C.	0	0
B	162	7-9	118 C.	0	0
Control lot....	77	7-9	30 C.	58	75.3

Experiment 14.—This test was carried out in a portable disinfector in which a pressure of 15 pounds was attained. Two wool socks were used with thermometer and nits in each. A was put in a roll of three blankets, two sweaters, one shirt, one blouse. At the sides and top of this roll, after it was in the bag, were stuffed one shirt, two pair socks, two pair breeches, two suits underwear. Bag tightly packed. B was put in roll of three blankets, two suits underwear, two shirts, one sweater, one bouse, one pair breeches. Alongside and on top of this roll were stuffed two pair socks, wrap leggings, cap and underwear. The sterilizer was loaded with eleven bags, the two test bags being near the front end of the carrier.

Treatment.—Preliminary vacuum, 12 inches, reached in 3 minutes; steam, 15 pounds, reached in 5 minutes, held 10 minutes, total 15 minutes; drying vacuum, 10 inches, reached in 5 minutes, held 5 minutes, total 10 minutes.

Results

Bag	Number of Eggs	Age of Eggs, Days	Maximum Temperature Recorded	Number Hatched	Percentage
A	128	6-8	94.5 C.	0	0
B	194	6-8	87 C.	0	0
Control lot....	163	6-8	30 C.	134	79.2

PRECAUTIONS TO BE OBSERVED

The following experimental data bring out some very practical points which have to be kept in mind if the process is to be efficient.

In the first place, less than 15 pounds pressure cannot be used with safety without lengthening the time of treatment. This was brought out in an experiment conducted at Plant No. 2 in a portable disinfector with safety valve adjusted so that only 12 pounds of steam was attained.

Experiment 11.—Two wool socks, each containing a thermometer and nits, were used as before.

Location in Bag.—The same as described for Experiment 12 above.

Location in Load.—There was a load of ten bags put in the sterilizer, and no one bag was completely surrounded by other bags, but had at least one side fully exposed. One test bag (A) was in a horizontal position near the center of the carrier, and the other (B) was in a vertical position at the rear end of the carrier.

Treatment.—Preliminary vacuum, 10 inches, reached in 2 minutes; steam, 12 pounds, 12 pounds reached in 4 minutes, held 11 minutes, total 15 minutes; drying vacuum, 10 inches, reached in 4 minutes, held 6 minutes, total 10 minutes.

Results

Bag	Number of Eggs	Age of Eggs, Days	Maximum Temperature Recorded	Number Hatched	Percentage
A	225	7-9	93 C.	0	0
B	287	7-9	51 C.	256	89.2
Control lot....	77	7-9	30 C.	58	75.3

Second, the sterilizers must not be overloaded. The tight packing necessary in an overload hinders penetration, especially in those bags in the center of the treated mass. This was shown in the following test:

Experiment 9.—This test was carried out at Plant No. 1 in the large stationary sterilizer during regular operations. Two wool socks were used as before, in each of which was placed a thermometer and a bit of cloth with eggs attached. Each was put in the roll of one of the enlisted men going through at the time.

Location in Bag.—A was put in center of a roll consisting of three blankets, one overcoat, one blouse, two O. D. wool shirts, one pair breeches, one extra suit underwear, one towel, four pair socks, one pair wrap leggings. B was put in another roll made up of practically the same amount of material except that there was one less O. D. shirt, and no towels, nor wrap leggings.

Location in Load.—A was placed in the center of the second row of bags in the carrier, with two bags below and two above it. B had the same position in the fifth row of bags near the other end of the carrier. The carrier was overloaded with eighty-nine bags, which were pressed together and tightly packed.

Treatment.—Preliminary vacuum, 10 inches, reached in 2 minutes, then steam was turned in; steam, 15 pounds, 10 pounds reached in 7 minutes, 15 pounds reached in 9½ minutes, held 5½ minutes, total 15 minutes; drying vacuum, 10 inches, reached in 6 minutes, held 4 minutes, total 10 minutes.

Results

Bag	Number of Eggs	Age of Eggs, Days	Maximum Temperature Recorded	Number Hatched	Percentage
A	185	5-7	41.5 C.	107	57.8
B	244	3-5	73 C.	0	0
Control lot....	118	3-5	30 C.	89	76.7

By way of comparison, the following test shows what a difference the location in a load makes.

Experiment 10.—This test was conducted in much the same manner as in the preceding one. Thermometers and nits were placed in socks and put in roll consisting of three blankets, one overcoat, one blouse, one pair breeches, one extra suit of underwear, socks, leggings and cap. The two rolls in this test were practically alike in amount of material and the method of packing.

Location in Carrier.—Both bags were placed on top the load, which was made up of ninety-three bags tightly packed in the carrier.

Treatment.—Preliminary vacuum, 10 inches, reached after 4 minutes; steam, 15 pounds, reached after 10 minutes, held 5 minutes, total 15 minutes; drying vacuum, 10 inches, reached after 6 minutes, held 4 minutes, total 10 minutes.

Results

Bag	Number of Eggs	Age of Eggs, Days	Maximum Temperature Recorded	Number Hatched	Percentage
A	310	3-5	105 C.	0	0
B	190	3-5	105 C.	0	0
Control lot	116	3-5	30 C.	89	76.7

The two experiments just described were carried out under practically the same conditions except for the location of the bags in the load. The amount of materials was the same in all. The bags were filled in the same way, and the treatment was the same. The difference in the location of the bags in the load had its effect on the results. These bags on top the load, and thus fully exposed, showed a good penetration, a temperature of over 105° C. being developed in the center of both. In those bags in the center of a heavy load (Expt. 9) penetration was rather poor. In one of the two the heat developed in the center of the bag was not sufficient to kill the nits.

A third point of importance to be borne in mind is the necessity of maintaining a full head of steam in the jacket of the sterilizer. With low pressure, the requisite 15 pounds pressure within is reached very slowly. This means failure to kill unless the time of exposure is lengthened, as in the following test.

EXPERIMENT 5.—This experiment was carried out at the large sterilizer at Sanitary Process Plant No. 1, in the course of regular operations. In each of two wool socks was placed a piece of cloth with nits attached and a self registering thermometer. Each sock was then placed in the roll of one of the enlisted men going through at the time. Each roll consisted of three blankets, one overcoat, blouse, breeches, two O. D. shirts, extra socks and underwear. The sock with the thermometer and eggs was rolled up in the center of this mass and the roll put in a barracks bag. The underwear worn by the men was, after inspection, placed on top of this roll in the mouth of the bag, which was then tied and tagged in the usual way.

The actual load in this test was ninety-three bags. Not all the bags, however, were completely filled, so that the carrier was not so much overloaded as the figures indicate.

Location of the Test Bags in the Carrier.—Bag A was placed on top of the load. Bag B was placed as near the center of the load as possible. It happened that the underwear worn by the man to whom Bag B belonged was infested with lice so that this offered a test on both the active and the egg stages of the lice.

Results

Bag	Number of Eggs	Age of Eggs, Days	Maximum Temperature Recorded	Number Hatched	Percentage
A	210	4-6	95.5 C.	0	0
B	140	2-4	104.5 C.	0	0
Control lot	155	4-6	30 C.	117	75.4

The lice in the infested underwear in Bag B were found to be dead.

Treatment.—Preliminary vacuum, 10 inches, reached in 3 minutes, held to end of 5 minutes; steam, 15 pounds, reached in 21 minutes, not held; drying vacuum, 10 inches, reached in 10 minutes, not held.

In the above experiment the steam pressure in the boilers was very low. Instead of establishing the required 15 pounds pressure in 7 or 8 minutes or less, and holding it for the remainder of a 15-minute-period, fully 21 minutes were consumed in reaching this pressure. The 15 pounds having been reached, it was released at once. The results are of interest therefore as indicating that penetration can be secured even when the steam pressure is low by a short extension of the time usually given for the application of the steam. It is assumed that the sterilizer is to be operated by one of sufficient intelligence to exercise good judgment in such circumstances. The failure to kill in one of the bags in the following test is to be explained on the ground that the pressure was rather low, requiring 9 minutes to reach the 15 pounds pressure.

Experiment 7.—Two wool socks, containing thermometer and nits, were used as in preceding experiments. Each was placed in the center of a roll of an enlisted man. The two rolls were practically alike as regards the amount of material. Each containing three blankets, one overcoat, one blouse, one pair breeches, extra suit underwear, one O. D. shirt, cap and wrap leggings. There was of course some difference in the way the rolls were made up, as no two men will make up a roll and fill their bags in exactly the same way.

Location in Load.—Actual load was seventy-three bags. Bag A was placed in second row with one bag below and two above. Bag B was placed in fifth row with two bags below and one above.

Treatment.—Preliminary vacuum, 10 inches, reached in 3 minutes; steam, 15 pounds, 15 minutes, 15 pounds reached in 9 minutes and held remainder of the period; drying vacuum, 10 inches, 10 minutes, 10 inches reached in 5 minutes and held 5 minutes.

Results

Bag	Number of Eggs	Age of Eggs, Days	Maximum Temperature Recorded	Number Hatched	Percentage
A	230	1-3	46.5 C.	217	94.3
B	292	1-3	96.5 C.	0	0
Control lot	122	1-3	30 C.	76	62.3

In Bag A all the contents of the bag was hot except for a very limited area near the center where the bulb of the thermometer happened to be located. In fact, the top part of the steel case protecting the thermometer was too hot to touch on removal while the bulb end was comparatively cool.

Fourth.—It is hardly necessary to point out the value of the preliminary vacuum in assisting the penetration of the steam. However, the following test is included as it brings out the point so clearly.

Experiment 8.—Three wool socks were used, each with a thermometer and a lot of eggs. Each was placed in the center of a roll consisting of three blankets, one overcoat, one blouse, one pair breeches, extra suit of underwear, two O. D. shirts, cap, socks and leggings.

Location in Load.—Actual load was eighty bags. Bag A was placed in second row, two bags below and one above. Bag B was placed in fourth row, two bags below and one above. Bag C was placed in fifth row, two bags below and one above.

Treatment.—Steam, 15 pounds, 15 minutes, 10 pounds reached in 8 minutes, 15 pounds reached in 13 minutes, held at this point for 2 minutes; drying vacuum, 10 inches, 7 minutes, 10 inches reached in 5 minutes.

Results

Bag	Number of Eggs	Age of Eggs, Days	Maximum Temperature Recorded	Number Hatched	Percentage
A	168	5-7	45 C.	111	66
B	220	3-5	37 C.	190	56.3
C	298	3-5	104.5 C.	0	0
Control lot	105	3-5	30 C.	90	85.7

It will be noted that each of the test bags contained about the same amount of material and had the same relative positions in the load. No preliminary vacuum was produced, and failure of penetration is marked in two bags.

Fifth. — The differences in the way the rolls are made up have important influence on penetration. The following test gave results which show failure to kill in one heavy roll tightly packed as compared with success in a light, loose roll.

Experiment 13.—This test was also conducted with the large sterilizer at Plant No. 1. Two wool socks with thermometers and nits in each were put in roll of enlisted men's equipment as follows: A was placed in roll consisting of three blankets, one blouse, one breeches, one O. D. shirt, one cap, two pair socks. B was placed in a roll consisting of three blankets, one overcoat, one blouse, one breeches, two O. D. shirts, one extra suit underwear, four pair socks, one cap, one pair wrap leggings. It will be noted that B was a much heavier roll than A, containing one overcoat, one shirt, one suit underwear, two pair socks and one pair wrap leggings in excess of the material in A. Further, it was kept in compact condition by a web belt which the owner placed around it.

Location in Load.—A was placed in the third row of bags with one bag below and one above. B was placed in the fifth row with one bag below and one above it. The load was a normal one of sixty-nine bags, and the two test bags were placed so as to be about equally exposed.

Treatment.—Preliminary vacuum, 10 inches, reached in 3 minutes; steam, 15 pounds, reached in 11 minutes, held 4 minutes, total 15 minutes; drying vacuum, 10 inches, reached in 5 minutes, held 5 minutes, total 10 minutes.

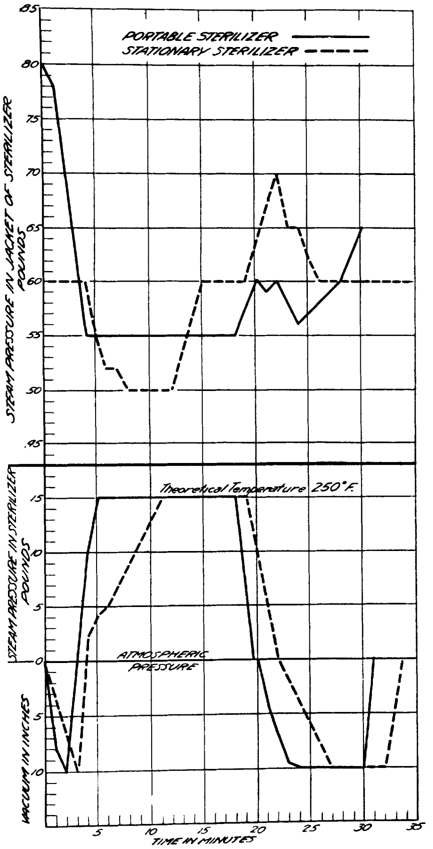
Results

Bag	Number of Eggs	Age of Eggs, Days	Maximum Temperature Recorded	Number Hatched	Percentage
A	210	5-7	85 C.	0	0
B	260	5-7	34 C.	244	94
Control lot	74	5-7	30 C.	46	62.1

In this experiment the difference between the two bags was in the amount of material they contained, and the fact that Roll B was kept tight by a belt. Location in the load and the treatment were the same. The results show that the penetration of the light roll (Bag A) was sufficient to kill all the nits, while in the heavy roll the heat failed to reach the center and none of the nits were killed. Bag B of course contains the usual amount of material which is ordinarily treated with success. The failure to kill was due to making the roll too tight.

A COMPARISON OF THE EFFICIENCY OF THE LARGE STATIONARY STERILIZER AND THE SMALL PORTABLE STEAM DISINFECTOR

A number of records were made of the operation of the sterilizers, noting minute by minute the pressure changes both in the sterilizers and in the jacket. Two of these records, selected because they show the usual changes when the sterilizers are operating well, have been charted (Fig. 1). It will be noted from this chart that the small portable sterilizers do the work more quickly than does the larger stationary one. The large sterilizer develops the 10 inch vacuum more slowly. It is also much slower in developing the 15 pounds steam pressure, and this is the most serious difference as regards practical results. Records show that the 15 pounds pressure is obtained in the portable sterilizer within 3 to 5 minutes from the time the steam is turned in. Reckoning the 15 minute period from the time the steam is turned on, the contents of the sterilizer is thus exposed to the 15 pounds pressure for 10 to 12 minutes.



Comparison of the pressure changes in the large stationary and small portable disinfectors during normal operation.

In the large stationary sterilizer, the records show that 4 to 11 minutes are required to produce the 15 pounds pressure, thus leaving only 4 to 11 minutes for the application of the pressure.

In every test with the portable sterilizer, the 15 minute period of steam at pressure of 15 pounds was efficient in producing a killing temperature (75° C. and above) in the center of barracks bags packed in the usual way. In one roll, the goods were rolled very tightly, and the man strapped his belt around the roll and kept it tight. On removal from the sterilizer there was one cool spot in the roll under the thick padding of the shoulders of the overcoat. With this exception, which was caused by unusual conditions, we have never found failure of penetration when the portable sterilizers were working with 15 pounds pressure. A 12 pound pressure, however, is not always efficient.

In tests with the large stationary sterilizer, it was found that in three out of ten cases, killing temperatures were not produced in the center of the bags. All of these cases were bags in the center of a large load in the carriers.

It is the writer's opinion that the accompanying chart shows the probable explanation of this difference in efficiency. The solid line, representing operation of the portable sterilizer, shows that, after the 10 inch vacuum was produced, 15 pounds steam was developed within 3 minutes after the steam was turned on, and held for 12 minutes. The broken line, representing action of the large sterilizer, shows that 8 minutes were necessary to raise the pressure to 15 pounds, leaving only 7 minutes during which the goods were exposed.

SHRINKAGE TESTS

Two tests were made to determine the amount of shrinkage resulting from the sterilization process now in use. They were both done in one of the portable sterilizers at Sanitary Process Plant No. 2.

In the first test, two wool blouses, one new and one a re-issue, were folded up with a thermometer in the folds, and put into a barracks bag. This bag contained nothing but the blouses, and was placed on top of a load of eleven bags in the sterilizer. The object was to subject them to the full effect of the heat. They were subjected to the following treatment:

Preliminary vacuum, 10 inches, reached in 2 minutes; steam, 15 pounds, 15 pounds reached in 6 minutes, held 9 minutes, total 15 minutes; drying vaccum, 10 inches, reached in 3 minutes, held 7 minutes, total 10 minutes.

The temperature recorded within the folds was 246° F., which is within 4 degrees of the temperature theoretically developed at 15 pounds pressure.

The blouses were shaken out until cool and dry.

	Measurements	Before Treatment Inches	After Treatment Inches
A	Between shoulders	16½	16¾
	Length of back	29¾	29¾
	Right sleeve, inner seam	19	18¾
	Right sleeve, outer seam	25	24½
B	Between shoulders	16¼	16
	Length of back	29½	29½
	Right sleeve, inner seam	18½	18½
	Right sleeve, outer seam	25	25¼

In the second test, an overcoat, blouse and breeches were rolled up with a thermometer in the center and placed in a barracks bag. Another blouse and breeches were put in a second bag. These two bags were put in sterilizer without any other load. All the clothing in this test was now and pressed. They were treated as follows:

Preliminary vacuum, 10 inches, reached in 2½ minutes; steam, 15 pounds, reached in 2 minutes, held 13 minutes, total 15 minutes; drying vacuum, 10 inches, reached in 2 minutes, held 8 minutes, total 10 minutes.

The temperature recorded in the center of the larger roll was 220° F. It was doubtless higher at the outside of the roll, probably most of the goods were exposed to 245° F.

The clothing was shaken out and measured a second time after they were cool and dry, with following results.

Measurements		Before Treatment Inches	After Treatment Inches
Overcoat.	Neck	19	18¾
	Length of back	41	40¾
	Right sleeve, outer seam	25	24¾
	Right sleeve, inner seam	19	18½
Blouse A.	Between shoulders	15	15
	Length of back	29¼	29
	Right sleeve, outer seam	25	25
	Right sleeve, inner seam	19¾	19½
Breeches B.	Waist	30	29½
	Left inner seam	26	26
	Left outer seam	38¾	38¼

The two following garments were folded loosely in another bag and probably were subjected throughout to a temperature of about 245 F.

Blouse C.	Between shoulders	15½	15½
	Length of back	28½	28¼
	Right sleeve, outer seam	24¾	24¼
	Right sleeve, inner seam	19¾	19
Breeches D.	Waist	31	31¼
	Left inner seam	26	26½
	Left outer seam	38¾	38½

The results show three measurements one-quarter inch longer after treatment; eight measurements remain the same, and fifteen measurements indicate slight shrinkage. The shrinkage averages only about one-tenth of one per cent. Allowance must be made for some variation in the manner of measuring, and also for the fact that the goods were not pressed after treatment before final measurements.

The above measurements are few in number. Nevertheless, it is safe to say that the sterilizing process as employed at this camp, causes very little if any shrinkage. There is no doubt, of course, that longer exposures to steam under pressure will cause more serious shrinkage. These results agree very well with those of Fulton and Staniford (1918).

CONCLUSIONS

If the penetration of steam is sufficient to produce a temperature of 75° C. (167° F.) in the center of a barracks bag (or other load of infected goods) all eggs and active stages of body lice will be destroyed. This conclusion, based on the above practical tests, agrees very well with laboratory experiments on fatal temperatures. Nuttall (1918) has shown that nits are killed in one minute at 70° C. in dry heat, and in 10 seconds at 70° C. moist heat.

If the disinfectors are operated efficiently on the time schedule now employed (viz., a 10 inch preliminary vacuum; 15 pounds steam pressure for 15 minutes, reckoned from the time the steam is turned on; followed by a 10 inch drying vacuum) the requisite temperature (75° C.) is attained in every case. By efficient operation is meant (1) the maintenance of a full head of steam so that the 15 pounds pressure in the disinfector is produced within 5 minutes, thus allowing at least 10 minutes for exposure; (2) overloading must be guarded against; (3) the individual bundles must not be rolled too tightly.

Little if any shrinkage of woolen goods is caused by this treatment. There is, of course, some wrinkling, but these wrinkles are not permanent but may be remedied by pressing.

The writer wishes to express his appreciation of the courtesy of the authorities of Camp Mills in permitting him to do this work in the camp, and especially to Lieut.-Col. James F. Edwards, Camp Surgeon, and Major Elmer Jackson, Assistant Camp Surgeon, for their active interest and help, and to the Surgeon-General's Office, War Department. for permission to publish the results.

Papers Cited

Fulton, D., and Staniford, K. J. 1918.—The Sterilization of Woolen Blankets and Uniforms. Jour. Am. Med. Assn., 71: 823.

Nuttall, G. H. F. 1918.—Combating Lousiness among Soldiers and Civilians. Parasitol., 10: 411-588.

Plotz, H. 1919.—The Importance of the Louse Problem. Jour. Am. Med. Assn., 72: 324-326.